AN IMAGE FORMING APPARATUS

FIELD OF THE INVENTION AND RELATED ART

The present invention relates to an image forming apparatus wherein a toner image is transferred from an image bearing member such as photosensitive drum onto a transfer material carried on a transfer material carrying member such as transfer drum, or transfer belt.

Generally, in a color image forming apparatus of electrophotographic type, a positive color tone is not provided if the image density variations due to various conditions such as ~~ambience change,~~ number of prints.

Therefore, in order to discriminate the circumstance during image formation, a toner image (patch) for maximum density (Dmax) detection for each color toner is formed on photosensitive drum as a test image, and the density thereof is detected by an optical sensor. The detection result is fed back to the image forming condition such as developing bias to maintain the Dmax for each toner at a predetermined level maximum density control (Dmax control). In order to provide a high quality image, the Dmax for each toner is desirably maintained at a predetermined level, and in addition, the tone gradient reproduction is also desirably correct. In view of this, a

plurality of half-tone patches from low density to high density are formed for each toner as test images, and the densities are detected. On the basis of the detection results, a correction (so-called γ ~~&g&~~ correction) is effected to provide a linear relation between the image signal and the resultant image density (half-tone control).

On the other hand, in order to downsize the main assembly of the device, diameter reduction of the photosensitive drum is effective. This is because the circumferential length of the transfer drum has to be at least the length of the transfer material usable with the apparatus.

In order to eliminate the necessity of the provision of a sensor around the photosensitive drum, it has been proposed to transfer a patch image formed on the photosensitive drum onto the transfer drum and then to detect the transferred patch image by a sensor provided adjacent the transfer drum.

However, there arises a problem that the first sheet after the density control with the patch image on the transfer material drum, involves back side contamination.

The cause has been found as being that the patch image formed for the density control is not completely cleaned with the result that the transfer drum is contaminated after the density control.

There is a problem that under the low humidity ambient condition ~~ambience~~ or high humidity ambient condition ~~ambience~~, correct image density, or color tone is not provided despite the density control being carried out.

This is because the correct density control is not carried out because of the deterioration of the transfer action due to the shortage of the transfer charge or the excess ~~coverage~~ of the transfer charge resulting in penetration due to the change of the patch toner polarity.

That is, when the image is transferred with low transfer efficiency as a result of transfer defect or penetration (thin image transfer), the density control increases the developing bias despite the fact that the satisfactory development is effected, resulting in the higher density developed image. Thus, positive image density is not provided, and the tone gradient reproducibility becomes poor.

SUMMARY OF THE INVENTION

Accordingly, it is a principal object of the present invention to provide a control system for an image forming condition of image forming means on the basis of detection of a toner image for density detection.

It is another object of the present invention to provide a transfer system for properly transferring

the toner image for the density detection onto the transfer material carrying member.

It is a further object of the present invention to provide a transfer system for a toner image for proper density detection despite the ambience condition change.

While the invention has been described with reference to the structures disclosed herein, it is not confined to the details set forth and this application is intended to cover such modifications or changes as may come within the purpose of the improvements or the scope of the following claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an illustration of an image forming apparatus according to embodiment 1 of the present invention.

Figure 2 is a major part illustration of a transfer device of an image forming apparatus according to embodiment 1. Figure 3 is a graph showing a relation ~~btjj~~ between a transfer current and Q/M of toner after the transfer.

Figure 4 is an illustration of an image forming apparatus according to embodiment 2 of the present invention.

Figure 5 is ~~as~~ an graph showing a transfer efficiency (for temperature/humidity, respectively)

during normal print

Figure 6 is a graph showing transfer efficiency (for temperature/humidity, respectively during density detection.

Figure 7 is a graph showing transfer efficiency (for respective PWM signal data) during density detection.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 is a sectional view of a full-color image forming apparatus of an electrophotographic type according to an embodiment of the present invention.

In the color image forming apparatus, an image bearing member 3 in the form of an electrophotographic photosensitive drum is rotated in a direction indicated by the arrow, and is charged uniformly by charging means 10 during the rotation, and thereafter, it is subjected to a light image projection by a laser exposure device 11 or the like so that the electrostatic latent image is formed on the photosensitive drum 3. The latent image is developed into a visualized image, namely toner image by developing devices 1a, 1b, 1c, 1d containing color developers such as yellow (Y), magenta (M), cyan (C), developers, for example, carried on a rotatable supporting member.

In this example, reverse development is used

wherein the toner is deposited on the low potential portion provided by the light projection.

On the other hand, the transfer material 7 is fixed by a gripper 5 on a transfer device 2, having a drum type transfer material carrying member. More particularly, it is electrostatically attracted on the transfer drum 2 by an attracting device 8. The attracting device 8 comprises, as shown in Figure 2, an aluminum core metal 21, an elastic layer 22, thereon and a dielectric layer 23 for attracting the transfer material on the surface thereof. The toner image on the photosensitive drum 3 is transferred onto a transfer material 7 wound around the transfer device, namely the transfer drum 2 in this example by applying a voltage between the aluminum core metal 21 functioning also as a transfer electrode and the elastic layer 22 from the voltage source 17.

More particularly, an electrostatic latent image formed on the photosensitive drum 3 by the exposure based on an image signal for a first color, is visualized by a developing device 1a accommodating the yellow (Y) developer, and thereafter, it is transferred onto the transfer material 7 carried on the transfer drum 2. Subsequently, the remaining developer on the photosensitive drum 3 is removed by a cleaner 12, and thereafter, an electrostatic latent image for the second color is formed on the

photosensitive drum 3 by the exposure based on an image signal for the second color. It is visualized by a developing device 1b having a magenta (M) developer, for example. Then, it is overlyingly on transferred on the transfer material 7 on the transfer drum 2 having the yellow visualized image. Subsequently, the same process is repeated, and the cyan (C), and black (Bk) toner images are overlyingly transferred onto the transfer material 7 on the transfer drum 2. Thereafter, the transfer material 7 is discharged by a separation discharger 6, and is separated from the transfer drum 2 by a separation claw 14, and the image is fixed by a fixing device 4 into a permanent image.

The transfer drum 2 after the transfer material 7 separation, is cleaned by a transfer member cleaner 13 so that the developer is removed from the surface thereof, and is discharged by a discharger 9 to be electrically initialized.

In this embodiment, the density detection is carried out in the following manner. First, a density detection patch image (patch) of the maximum density (Dmax) of yellow (Y) is formed on the photosensitive drum 3. The patch is transferred onto the transfer drum 2, and the density of the patch is detected by a density sensor 15. Subsequently, a patch image for the Dmax detection is formed with magenta (M) color toner on the photosensitive drum 3, and is transferred onto

the transfer drum at a position different from that of the Y toner patch. The density of the patch is detected by the density sensor 15. Similarly, the densities of the cyan (C), and black (Bk) toner images are detected to effect the Dmax control. The order of the colors of the patch images for the density detection may be different.

On the basis of the output of the density sensor, the image forming condition such as ~~a~~ an application voltage, or developing bias of the charger 10 is controlled.

In this embodiment, a transfer intensity upon the transfer of the density detection patch image onto the transfer drum 2, is made smaller than the transfer intensity upon the transfer of the toner image onto the transfer material 7 carried on the transfer drum 2.

Therefore, the patch image can be easily removed.

In this embodiment, in order to reduce the transfer intensity, the transfer bias V_{pat} applied from the voltage source 17 upon the density detection operation is made smaller than the transfer bias V_{tr} applied from the voltage source 17 upon the transfer of the toner image onto the transfer material.

Preferably, $V_{pat} \leq (4/5)V_{tr}$ is satisfied.

Conventionally, the transfer bias upon

density detection is the same as the transfer bias upon the normal print. However, the total electrostatic capacity of the nip is larger during the density detection than during the normal print, corresponding to the absence of the transfer material, and therefore, a larger transfer current flows during density detection if the same bias voltage is applied.

In a transfer drum type as in this embodiment, the larger the transfer current (positive) as shown in Figure 3, the larger the charge of the opposite polarity (negative) from the transfer charge is induced in the toner, with the result of higher Q/M ($-\mu C/g$) of the toner after the transfer increases.

By application of the charge (positive) of the same polarity as the transfer onto the rear surface of the dielectric layer 23, the air is ionized in the small clearance downstream of the nip between the transfer drum 2 and the photosensitive drum 3, so that negative charge is applied on the surface of the dielectric layer 23 ~~layer 23 and the dielectric layer 23. This is the reason.~~

Thus, with increase of the negative charge of the toner and the positive charge on the dielectric layer 23 rear surface, the Coulomb force between the toner and the transfer drum dielectric layer 23 increases, and therefore, the cleaning property becomes ~~become~~ poor.

The following Table 1 shows a relation between the transfer bias for the first color density detection and cleaning property :

TABLE 1 (First Color)

Vtr1=1000V

Transfer Bias (V)	300	500	800	900	1000	1200
Cleaning Property	G	G	G	F	NG	NG

G: good

F: fair

NG: No good

Here, upon 1000V of transfer bias, the transfer current is 14.1μA, and upon 900V, the current is 10.6μA, and upon 800V, it is 7.2μA. It is understood that with the increase of the transfer current, the Q/M of the toner after the transfer increases with the result of the poor cleaning property. Tables 2-4 show relations between the transfer biases for the density detections for the second to the fourth colors and the cleaning property.

TABLE 2 (Second color)

VTr2 = 1200V

Transfer Bias (V)	550	900	1000	1100	1200	1400
Cleaning Property	G	G	F	NG	NG	NG

TABLE 3 (Third color)
VTr3 = 1400V

Transfer Bias (V)	600	1100	1200	1300	1400	1600
Cleaning Property	G	G	F	NG	NG	NG

TABLE 4 (Fourth color)
VTr4 = 1400V

Transfer Bias (V)	650	900	1200	1400	1600	1800
Cleaning Property	G	G	G	F	NG	NG

It has been found that there is an interrelation between the transfer bias and the cleaning property for each color upon the density detection and the transfer bias upon the normal print, more particularly, if the transfer bias during the density detection is not more than 4/5 of the transfer bias during the normal print, the cleaning property is good. In this embodiment, the photosensitive drum is of OPC having a negative charging property. It comprises a charge generating layer and the charge transfer layer having a thickness of 25 microns. The transfer drum comprises a core metal 21 of aluminum as a transfer electrode, an elastic member 22 having a thickness of mm ~~5.5~~ aluminum and a volume resistivity of10^4Ohm.cm or smaller, and a dielectric member 23

a having a thickness ~~thickens~~ of 75μ ~~75mm~~ and a volume resistivity of 10^{14}-10^{16}Ohm.cm. The transfer bias during the normal print was 1000V, 1200V, 1400V, 1600V, for the first to fourth colors, and the transfer bias upon density detection was 500V, 550V, 600V, 650V, by which the cleaning was easy, and the back side contamination of the first sheet after the density control could be prevented.

If the transfer bias during the transfer of the density detection patch is too small, the transfer efficiency of the patch image is low, and therefore, the $V_{pat} \geq (1/5)V_{tr}$ is preferable.

In this embodiment, the transfer biases are different during the density detection and the normal print, but the DC current to be supplied from the voltage source 17 during the density detection may be made smaller than the normal print.

Embodiment 2

Referring to Figure 4, a second embodiment will be described. The same reference numerals as in the first embodiment are assigned to the elements having the corresponding functions, and detailed descriptions thereof are omitted for simplicity. In this embodiment, the temperature/humidity of the ambience is detected by an ~~ambient condition~~ detecting sensor 16, and the transfer bias is changed on the basis of the detection result.

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In this embodiment, even if the temperature/humidity of the ambient condition ~~ambience~~ changes, the transfer of the patch image during the density detection is made optimum and the proper density control is assured. If the temperature/humidity of the ambient condition ~~ambience~~ changes, the resistance~~,~~ and the electrostatic capacity of the dielectric layer 23 and the like change. For example, under a low temperature and low humidity ambient condition ~~ambience,~~ the resistance of the dielectric layer 23 is high, and the electrostatic capacity is low. The resistance and electrostatic capacity of the transfer material 7 changes. In this embodiment, the toner is transferred onto the transfer drum 2 by the potential difference between the photosensitive drum 3 and the transfer drum 2. Therefore, when the electrostatic capacity at the transfer position decreases, the potential difference between the photosensitive drum 3 and the transfer drum 2 reduces as compared with the case of the normal temperature/normal ~~temperature normal~~ humidity ambient condition ~~ambience~~ even if the same bias is applied. So, improper transfer results. On the contrary, under a high temperature and high humidity ambient condition, ~~ambience,~~ the potential difference is large with the result of discharge at the transfer position, and therefore, ~~the~~ improper transfer.

In this embodiment, in order to provide a high transfer efficiency irrespective of the ambient

condition change, the temperature and humidity in the device are detected by a sensor 16, and the transfer bias is controlled on the basis of the detection result.

For example, as shown in Figure 5, during the normal print, the transfer bias for the first color is 800(V), under 38°C, 80% ~~ambience,~~ and 1000(V), under 23°C, 60% ~~ambience,~~ and 1200(V) under 15°C, 10% ~~ambience.~~

As shown in Table 5 and ~~Table~~ Figure 5, the transfer bias for the density detection is controlled on the basis of the detection result of the sensor 16.

This is because there is no transfer material 7 at the transfer position during the density detection, but the electrostatic capacity of the dielectric layer 23 changes depending on the ambience.

During the density detection, there is ~~not~~ no transfer material 7 in the transfer position, and therefore, the total electrostatic capacity is larger than during the normal print operation.

Accordingly, as shown in Table 5, for example, during the density detection, transfer bias, for the first color is 350(V), under 30°C, 80% ~~ambience,~~ and 500(V), under 23°C, 60% ~~ambience,~~ and 700(V) under 15°C, 10% ~~ambience.~~

In this embodiment, transfer bias for the density detection is smaller than the transfer bias

for the normal print under the same ambient ~~condition.~~ conditions.

In this embodiment, the photosensitive drum is of OPC having a negative charging property. It comprises a charge generating layer and the charge transfer layer having a thickness of 25 microns. The transfer drum comprises a core metal 21 of aluminum as a transfer electrode, an elastic member 22 having a thickness of ~~5.5~~ 5.5mm core metal 21 and a volume resistivity of10^4Ohm.cm or smaller, and a dielectric member 23 having a ~~thickens~~ thickness of ~~75mm~~ 75μ and a volume resistivity of10^{14}-10^{16}Ohm.

TABLE 5

	15°C10%	23°C60%	30°C80%
Bias for first color	700V	500V	350V
Bias for second color	770V	550V	380V
Bias for third color	840V	600V	410V
Bias for fourth color	910V	650V	440V

Embodiment 3

The same reference numerals as in the foregoing embodiments are assigned to the elements having the corresponding functions, and detailed descriptions thereof are omitted for simplicity. In

this embodiment, density control process includes a ~~first control process for Dmax control, and a second, and the V_{HT} satisfy:~~

$$VDmax > V_{HT}$$

In this embodiment, the transfer is optimized by both of the Dmax control and the half-tone control. More particularly, in the Dmax control, one patch image data corresponding to a certain density, FOH of PWM signal, for example, is formed with varied developing bias. In the half-tone control, a plurality of low density patch images corresponding to 10H, 20H, 40H, 80H, are formed. At this time, the patch images of different PWM signal data have different latent image potentials, since the exposure amounts are different. In this embodiment, the latent image potential when the PWM signal data is FOH, is -220V, and -580V when it is 10H. In this embodiment, the toner is transferred onto the transfer drum by the potential difference between the photosensitive drum and the transfer drum. Therefore, if the latent image potential is different, the most preferable transfer bias is different.

Figure 7 shows a relation between the transfer bias and the transfer efficiency upon the density detection relative to different PWM signal data.

With a decrease of the PWM signal, the most

preferable transfer bias decreases, and with the increase of the PWM signal, the most preferable transfer bias increases.

If only the patches for 10H to 80H are looked at, the most preferable transfer is possible with the same bias voltage. Therefore, in this embodiment, the transfer bias during the Dmax control is 500V, and the transfer bias during the half-tone control is 350V, by which the transfer for both can be optimized. The density control is proper, and the ~~the the~~ correct image density, and color tone are provided.

Most Preferable ~~preferab~~ transfer biases may be set for the PWM signals of 10H to 80H, respectively.

It is preferable to detect the temperature/humidity of the ambient conditions ~~ambience,~~ and the transfer bias is controlled on the basis of the result of the detection.

In this embodiment, the photosensitive drum is of OPC having a negative charging property. It comprises a charge generating layer and the charge transfer layer having a thickness of 25 microns. The transfer drum comprises a core metal 21 of aluminum as a transfer electrode, an elastic member 22 having a thickness of 5.5 mm on ~~5.5~~ core metal 21 and a volume resistivity of10^4Ohm.cm or smaller, and a dielectric member 23 having a thickness ~~thickens~~ of 75μ ~~75mm~~ and a volume resistivity of10^{14}-10^{16}Ohm.. The description is

omitted for the second and subsequent colors, since there are the same tendencies.

While the invention has been described with reference to the structures disclosed herein, it is not confined to the details set forth and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.